

## §57. Transport Analyses of Carbon Atoms in the LHD Divertor Region

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The deterioration of the plasma energy confinement due to radiation by carbon ions originated from graphite divertor plates is a major concern in LHD plasma discharges. The reduction of carbon ions in the plasma periphery can mitigate radiation collapse which is often observed in high density plasmas in LHD.

Since the 6th experimental campaign, we have observed impurity (carbon ions) radiation profile in the lower divertor region in 2.5-L port with filtered CCD cameras ( $\lambda_0=426.7\text{nm}$  for CII,  $\lambda_0=465.4\text{nm}$  for CIII). The cameras can directly observe the graphite divertor plates, divertor legs and an X-point. Figure 1 shows the time evolution of the image of the radiation profile of carbon ions (CII and CIII) in the lower divertor region in which the plasma density was slightly increased by controlling the fueling rate from a gas puffer ( $R_{ax}=3.75\text{m}$ ). Significant increase of the radiation of CII in on a lower divertor leg (left side) was observed as the plasma density rise. The plasma discharge was terminated by radiation collapse

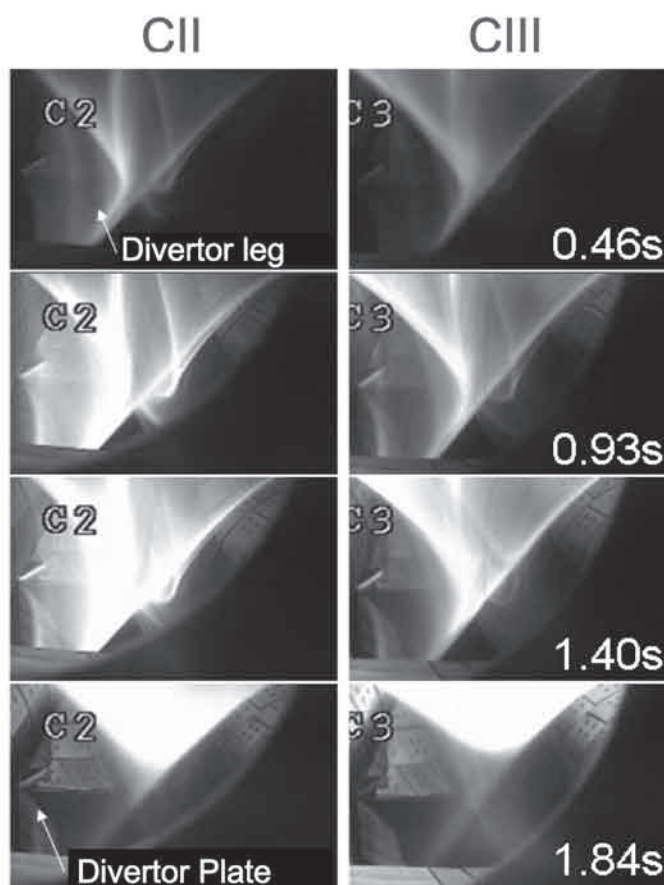


Fig. 1. The time evolution of the image of the emission profile from carbon ions (CII and CIII) in the lower divertor region. In this discharge, the plasma density was slightly increased by controlled gas fueling.

occurred at 1.84s, at which the divertor legs was not clearly observed and the radiation in the main plasma significantly increased.

These observations strongly suggest that the radiation by carbon ions from the graphite divertor plates affects the radiation collapse and limits the plasma density. For detailed analyses of the transport of carbon ions in the divertor region, we calculated the profile of neutral carbon atoms by using three-dimensional neutral particle transport simulation code (EIRENE stellarator version)<sup>1)</sup>. Figure 2 gives the calculation of the density profile of carbon atoms at a toroidal position where the plasma is vertically elongated. Neutral hydro-carbons ( $\text{CH}_4$ ) are emitted from divertor plates in this calculation, and the three-dimensional profile of the emitted hydro-carbons is based on the calculation of magnetic field line traces from the last closed magnetic surface. The input plasma parameter profiles are determined by the experimental results measured with plasma diagnostic systems just before the radiation collapse. The simulation shows the high density of the carbon atoms on inner divertor legs. In figure 1, the divertor leg (left side) on which high emission from carbon ions appeared corresponds to the inner and lower divertor leg. The calculation using the neutral particle transport simulation code can qualitatively explain the observations of the behavior of carbon atoms just before the radiation collapse.

In the near future, this analysis will contribute to the detailed investigation of plasma wall interactions and impurity transport in the divertor region, and to the achievement of higher density plasmas. It is also useful for the design of optimized closed divertor configurations planned in Phase II in LHD.

### Reference

- 1) Reiter, D. et al.: Plasma Phys. Contr. Fusion 33 (1991) 1579.

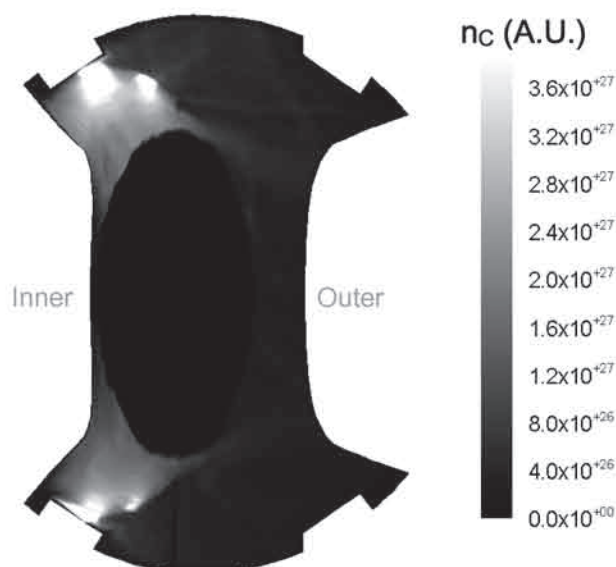


Fig. 2. The calculation of the density profile of carbon atoms just before the radiation collapse. In this calculation, methane is emitted from divertor plates on the basis of the calculation of magnetic field line traces.